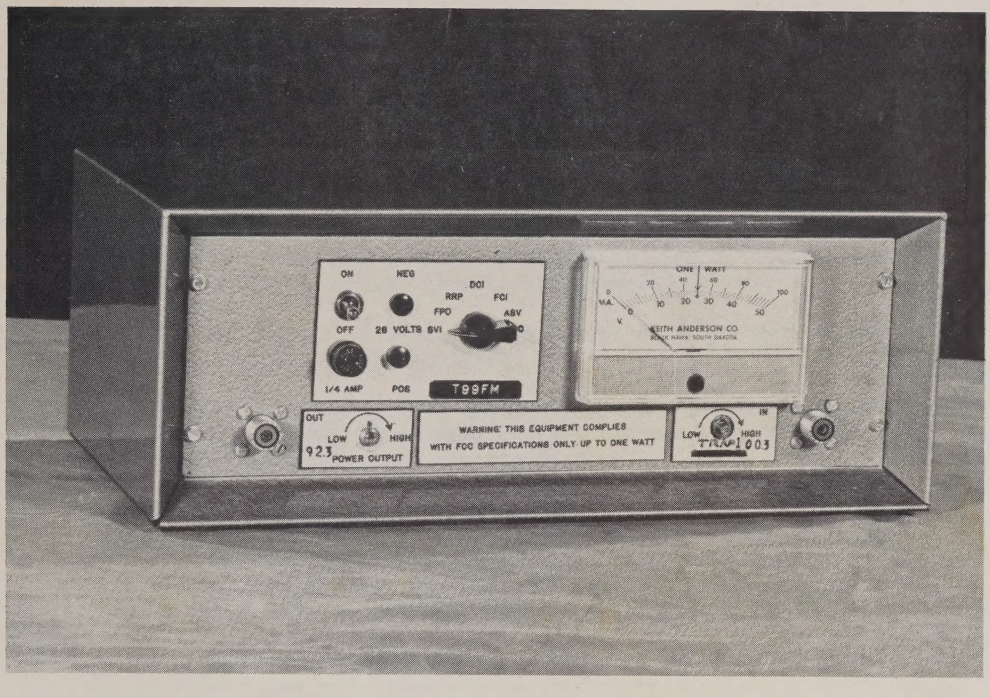

T99FM

ONE WATT
TRANSISTOR RADIO TRANSLATOR

KEITH ANDERSON CO.
BLACK HAWK, SOUTH DAKOTA

AREA 605
PHONE 787-4224

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T99 FM DESCRIPTION

The T99 FM one watt solid state translator is designed for the rebroadcast of F.M. radio channels in the 88.1 to 107.9 MHz range. It will receive imputs as low as 50 microvolts, convert to a different channel, and rebroadcast with one watt power output.

The power output is rigidly maintained by amplified automatic gain control. One watt will provide good quality line of sight coverage up to 50 miles through directional antenna systems.

Input signals as low as 5 microvolts may be utilized when amplified by an optional 20 dB. preamplifier.

The T99 FM requires only four watts D.C. power from the regulated 28 volt supply. This efficiency enables thermoelectric or battery powering at locations which are remote from A.C. main lines.

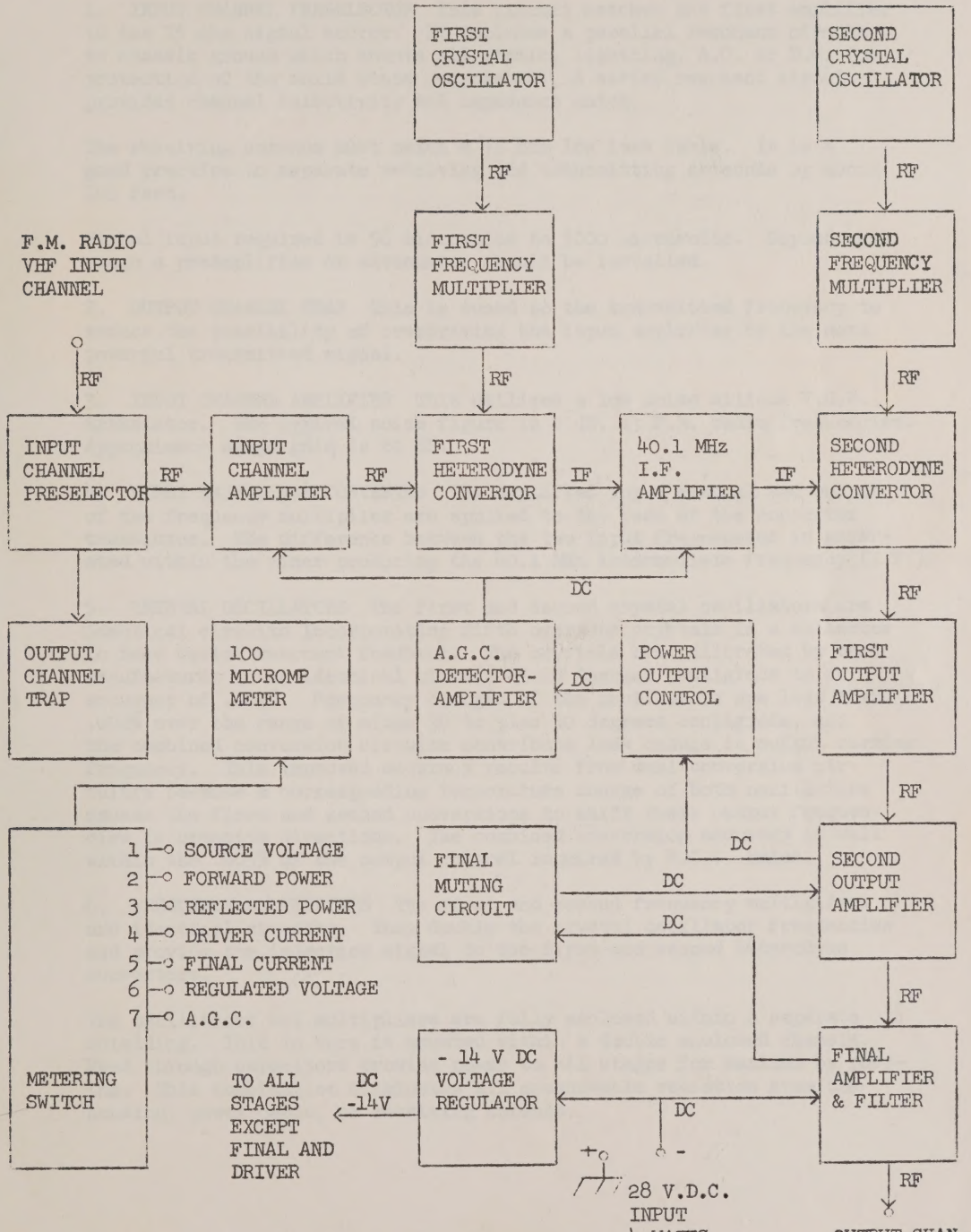
The translator uses components and circuits which are very similar to the proven quality T-99 television translator. Many of those have operated for over seven years with no maintenance and no loss of transmission quality. The dependability and efficiency of the T-99 has never been equalled by any other translator in the world!

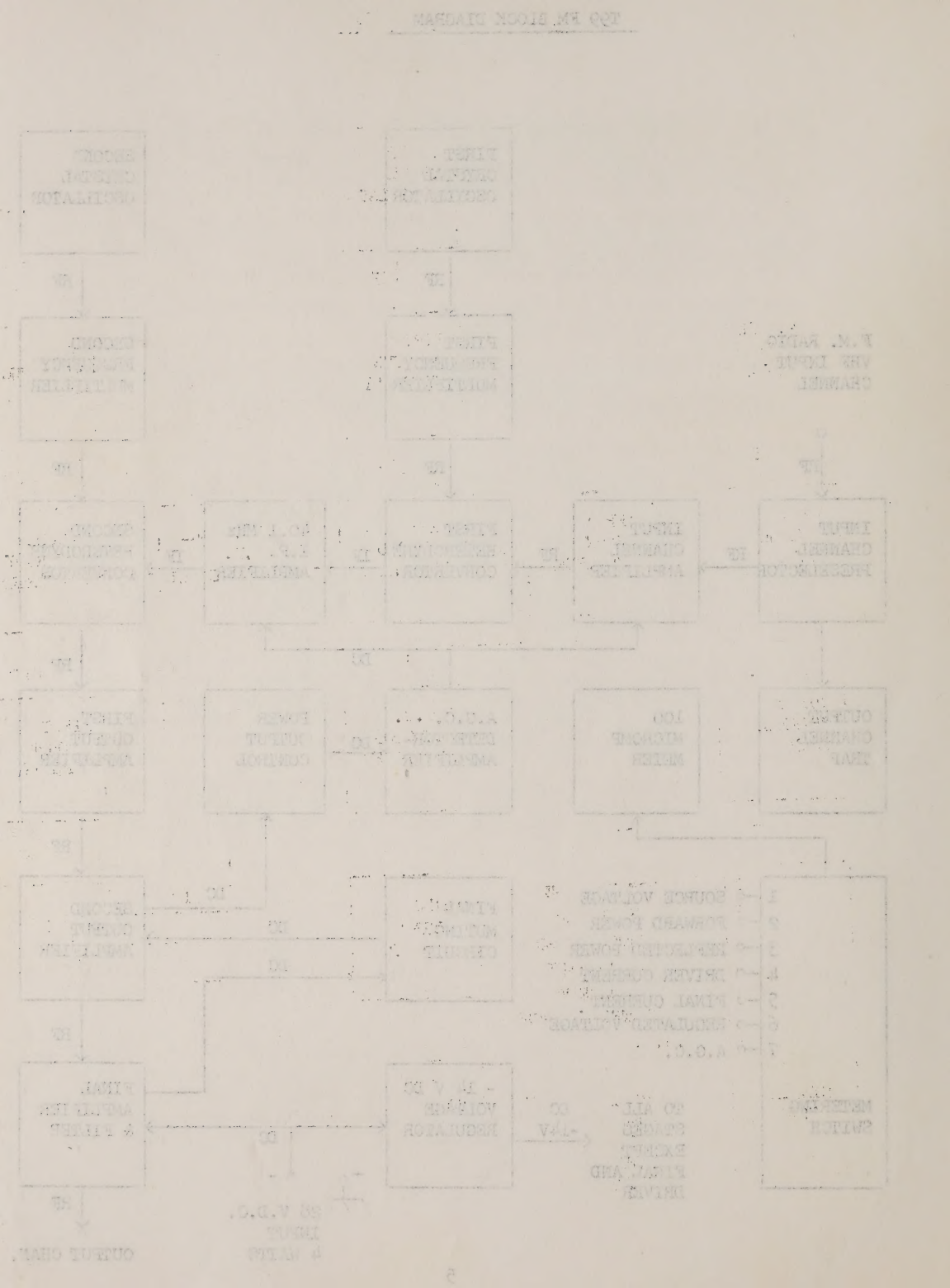
Low level dual conversion circuitry minimizes spurious frequencies, and provides excellent linearity for quality reproduction of stereo, monaural, and storecasting signals.

The T99 FM weighs only 12 pounds. The shadow housing dimensions are 6 by 9 by 15½ inches, and it is completely enclosed and dust proof. It has built in metering for power output, final stage inputs, power source voltage, relative reflected power, regulated amplified voltage, and automatic gain control.

All silicon transistors are incorporated for long life and dependability. All components operate cool without fan or ventilation holes. There is no electrical shock possible at the low operational voltage.

T99 FM BLOCK DIAGRAM





1. INPUT CHANNEL PRESELECTOR This circuit matches the first amplifier to the 75 ohm signal source. It includes a parallel resonant circuit to chassis ground which shunts all static, lightning, A.C. or D.C. for protection of the solid state components. A series resonant circuit provides channel selectivity and impedance match.

The receiving antenna must match a 75 ohm low loss cable. It is a good practice to separate receiving and transmitting antennas by about 100 feet.

Signal input required is 50 microvolts to 5000 microvolts. Beyond this range a preamplifier or attenuator should be installed.

2. OUTPUT CHANNEL TRAP This is tuned to the transmitted frequency to reduce the possibility of overdriving the input amplifier by the more powerful transmitted signal.

3. INPUT CHANNEL AMPLIFIER This utilizes a low noise silicon V.H.F. transistor. The typical noise figure is 4 dB. at F.M. radio frequencies. Approximate stage gain is 20 dB.

4. FIRST HETERODYNE CONVERTER The amplified input channel and output of the frequency multiplier are applied to the base of the converter transistor. The difference between the two input frequencies is generated within the mixer producing the 40.1 MHz intermediate frequency (I.F.).

5. CRYSTAL OSCILLATORS The first and second crystal oscillators are identical circuits incorporating fifth overtone crystals in a collector to base series resonant feedback. The crystals are calibrated by the manufacturer in an identical circuit at 20 degrees centigrade to an accuracy of .001%. Frequency changes of the oscillators are less than .002% over the range of minus 30 to plus 50 degrees centigrade, and the combined conversion circuits contribute less change in output carrier frequency. This improved accuracy results from dual conversion circuitry because a corresponding temperature change of both oscillators causes the first and second conversions to shift their output frequencies in opposite directions. The combined conversion accuracy is well within the .005% of the output channel required by F.C.C. rules.

6. FREQUENCY MULTIPLIERS The first and second frequency multipliers are identical circuits. They double the crystal oscillator frequencies and provide the injection signal to the first and second heterodyne convertors.

The oscillators and multipliers are fully enclosed within a separate shielding. This in turn is mounted within a double enclosed chassis. Feed through capacitors provide power to all stages for maximum by passing. This combination eliminates all measureable radiation from the housing, power cable, or receiving antenna.

7. 40.1 MHz I.F. AMPLIFIER The intermediate frequency amplifier is a selective high gain stage with double tuned input and output circuitry. It is an automatic gain controlled stage and combined with the input stage maintains over 40 dB. of A.G.C. with less than 2 dB. output variation. All of the T99 FM voltage amplifiers are Class A.

8. SECOND HETERODYNE CONVERTER The 40.1 MHz I.F. frequency and output of the second multiplier are applied to the base of the second converter. The difference frequency produced is the output channel. Because subtractive conversion is utilized in both mixers, the band pass is inverted in the I.F. but returns to normal in the output channel.

9. FIRST OUTPUT AMPLIFIER This stage is operated with higher input power than earlier stages to provide good linearity at the higher signal level. It is a silicon class A. amplifier double tuned to the output channel.

10. SECOND OUTPUT AMPLIFIER This driver stage delivers one tenth watt F.M. carrier to the input of the final. The A.G.C. is detected from the D.C. current to this class AB amplifier. Level of action of the automatic gain control is adjusted by the power output control.

11. FINAL OUTPUT AMPLIFIER The class AB final has a base circuitry which was experimentally derived for optimum linearity. It operates with an efficiency of approximately 50%. This stage is the heart of efficient translator performance. It enables higher quality rebroadcast than tube units requiring fifty times the supply power.

12. OUTPUT CHANNEL FILTER This is a triple tuned circuit with high capacitance parallel resonant output for shunting of harmonics and protection from lightning and static on transmitting cable. Traps are incorporated for any required frequencies. Output impedance is adjusted to match a 75 ohm antenna system.

13. AUTOMATIC GAIN CONTROL is detected as D.C. variance in driver collector current. Power output is proportional to driver current, so rigid regulation of this current controls the output level. A.G.C. is filtered then amplified by a high gain silicon D.C. amplifier for rigid control.

14. FINAL MUTING places the translator in a non-radiating condition in the absence of an input channel signal or an internal failure of the receiving circuits. This is accomplished by reverse bias of the base which gives better collector current cut off and muting than simply switching off final stage power.

The action is achieved by a bistable dual bias network which operates as a function of current utilized by all stages prior to the final. An input signal increases driver and A.G.C. stage currents causing the final base to bias for normal operation.

During no signal (standby) operation the base is reverse biased creating an effective open R.F. circuit. Noise pulses are prevented from activating the "turn on" by A.G.C. delay circuitry.

15. VOLTAGE REGULATOR is a solid state series transistor with zener diode control of base. It delivers -14 volts regulated D.C. to all pre-driver stages including the oscillators. This eliminates all frequency variation with change in power source voltages, and maintains stable amplifier characteristics over a large range of supply variations.

16. METER AND SWITCH All major functions are monitored by a single 100 microamp meter and seven position switch. Power output is factory calibrated by positioning the forward power detector coupling for one watt reading while operating in to a 75 ohm calibrated external R.F. meter.

The current and voltage input metering for the final and driver stages enable a secondary check on the power output based on the typical efficiency and input power. Two watts of final stage input yield an output of very nearly one watt. (This equals 72 milliamps at 28 volts D.C. input).

The amplifier stage voltage metering verifies proper operation of the supply regulator.

A.G.C. metering will give an indication of the relative input. Reading is decreased by increasing signal level. It will read about midscale when the unit is operated with the ideal one millivolt input level. This switch position can be used to "home in" directional receiving yagi antennas for lowest meter reading.

T99 FM TECHNICAL SPECIFICATIONS

INPUT FREQUENCY (SINGLE CHANNEL)	88.1 to 107.9 MHz
INPUT CHANNELS (U.S.)	201 to 300
INPUT LEVEL	50 to 5000 MICROVOLTS
INPUT AND OUTPUT IMPEDANCE	75 OHMS - COAXIAL
OUTPUT FREQUENCY	88.1 to 107.9 MHz
OUTPUT - INPUT, MINIMUM SEPARATION	2 MHz BETWEEN CHANNELS
OUTPUT LEVEL	ONE WATT
EMISSION TYPES	F-3 OR F-9
FREQUENCY RESPONSE	200 KHz ($\pm$1 DB.)
SPURIOUS OUTPUT ATTENUATION MINIMUMS	
120 to 240 KHz FROM CENTER FREQUENCY	30 DB.
240 to 600 KHz FROM CENTER FREQUENCY	40 DB.
OVER 600 KHz FROM CENTER FREQUENCY	70 DB.
ALL HARMONICS	70 DB.
AUTOMATIC GAIN CONTROL	40 DB. for 1 DB. OUTPUT VARIATION
CONVERSION ACCURACY	.005% OF OUTPUT FREQUENCY
POWER REQUIREMENTS - TRANSMIT	28 VOLTS D.C., 4 WATTS
POWER REQUIREMENTS - STANDBY	28 VOLTS D.C., 1 WATT
POWER SUPPLY OPTION	117 V.A.C. 50-60 CYCLES 6 WATTS
AMBIENT TEMPERATURE	-30 TO +50 DEGREES CENTIGRADE
DIMENSIONS	6 BY 9 BY 15½ INCHES
WEIGHT	12 POUNDS (5.5 KGM)
METERING	SUPPLY VOLTAGE, POWER OUTPUT, REFLECTED POWER, DRIVER CURRENT, FINAL CURRENT, REGULATED D.C., AUTOMATIC GAIN CONTROL.
POWER POLARITY	POSITIVE GROUND
LIGHTNING PROTECTION	INTERNAL - D.C. GROUND AT BOTH RF TERMINALS
TRANSMISSION SIGNALS	F.M. STEREO, MONAURAL AND SCA.
INTERMEDIATE FREQUENCY	40.1 CENTER (40 TO 40.2 MHz)
CONVERSION	DUAL - HETERODYNE

T99 FM CHANNEL CONVERSIONS

INPUTS AND OUTPUTS TO AND FROM 40.1 MHz I.F. *
EXAMPLE: CONVERT CHANNEL 201 to 212. FIRST OSCILLATOR MULTIPLIER = 64.1 - 128.2
SECOND " " = 65.2 - 130.4

CHAN.	FREQ.	OSC.	MULT.	CHAN.	FREQ.	OSC.	MULT.	CHAN.	FREQ.	OSC.	MULT.
201	88.1	64.1	128.2	234	94.7	67.4	134.8	267	101.3	70.7	141.4
202	88.3	64.2	128.4	235	94.9	67.5	135.0	268	101.5	70.8	141.6
203	88.5	64.3	128.6	236	95.1	67.6	135.2	269	101.7	70.9	141.8
204	88.7	64.4	128.8	237	95.3	67.7	135.4	270	101.9	71.0	142.0
205	88.9	64.5	129.0	238	95.5	67.8	135.6	271	102.1	71.1	142.2
206	89.1	64.6	129.2	239	95.7	67.9	135.8	272	102.3	71.2	142.4
207	89.3	64.7	129.4	240	95.9	68.0	136.0	273	102.5	71.3	142.6
208	89.5	64.8	129.6	241	96.1	68.1	136.2	274	102.7	71.4	142.8
209	89.7	64.9	129.8	242	96.3	68.2	136.4	275	102.9	71.5	143.0
210	89.9	65.0	130.0	243	96.5	68.3	136.6	276	103.1	71.6	143.2
211	90.1	65.1	130.2	244	96.7	68.4	136.8	277	103.3	71.7	143.4
212	90.3	65.2	130.4	245	96.9	68.5	137.0	278	103.5	71.8	143.6
213	90.5	65.3	130.6	246	97.1	68.6	137.2	279	103.7	71.9	143.8
214	90.7	65.4	130.8	247	97.3	68.7	137.4	280	103.9	72.0	144.0
215	90.9	65.5	131.0	248	97.5	68.8	137.6	281	104.1	72.1	144.2
216	91.1	65.6	131.2	249	97.7	68.9	137.8	282	104.3	72.2	144.4
217	91.3	65.7	131.4	250	97.9	69.0	138.0	283	104.5	72.3	144.6
218	91.5	65.8	131.6	251	98.1	69.1	138.2	284	104.7	72.4	144.8
219	91.7	65.9	131.8	252	98.3	69.2	138.4	285	104.9	72.5	145.0
220	91.9	66.0	132.0	253	98.5	69.3	138.6	286	105.1	72.6	145.2
221	92.1	66.1	132.2	254	98.7	69.4	138.8	287	105.3	72.7	145.4
222	92.3	66.2	132.4	255	98.9	69.5	139.0	288	105.5	72.8	145.6
223	92.5	66.3	132.6	256	99.1	69.6	139.2	289	105.7	72.9	145.8
224	92.7	66.4	132.8	257	99.3	69.7	139.4	290	105.9	73.0	146.0
225	92.9	66.5	133.0	258	99.5	69.8	139.6	291	106.1	73.1	146.2
226	93.1	66.6	133.2	259	99.7	69.9	139.8	292	106.3	73.2	146.4
227	93.3	66.7	133.4	260	99.9	70.0	140.0	293	106.5	73.3	146.6
228	93.5	66.8	133.6	261	100.1	70.1	140.2	294	106.7	73.4	146.8
229	93.7	66.9	133.8	262	100.3	70.2	140.4	295	106.9	73.5	147.0
230	93.9	67.0	134.0	263	100.5	70.3	140.6	296	107.1	73.6	147.2
231	94.1	67.1	134.2	264	100.7	70.4	140.8	297	107.3	73.7	147.4
232	94.3	67.2	134.4	265	100.9	70.5	141.0	298	107.5	73.8	147.6
233	94.5	67.3	134.6	266	101.1	70.6	141.2	299	107.7	73.9	147.8
								300	107.9	74.0	148.0

* I.F. FREQUENCY MAY BE OFFSET BY SPECIAL ORDER WHEN LOCAL CONDITIONS REQUIRE.

	SWITCH POSITION	METERING INDICATES	READING WITH (NO INPUT SIGNAL)	READING WITH 1 MILLIVOLT INPUT	SCALE READ
*	1-SVI	SOURCE VOLTAGE INPUT	28	28	VOLT
	2-FPO	FORWARD POWER OUTPUT	0	1 WATT	CENTER
	3-RRP	RELATIVE REFLECTED POWER	0	5 MAX.	VOLT
	4-DCI	DRIVER CURRENT INPUT	2	20-30	MA
	5-FCI	FINAL CURRENT INPUT	0	60-90	MA
	6-ASV	AMPLIFIER REGULATED VOLTAGE	14	14	VOLT
	7-AGC	AUTOMATIC GAIN CONTROL	80	50	MA

* The source voltage read in position one also equals the final collector voltage for power measurements based on efficiency. (Power output approximately equals final voltage times current in milliamps divided by 2000).

* The supply or source voltage can be read with the translator power switch off. This enables a preliminary check of the D.C. supply polarity and voltage before powering the T99 FM.

* With the translator power switch in the OFF position, and the internal metering in the SVI position, the D.C. power input jacks may be used for D.C. voltage measurements up to 50 volts (10,000 ohm per volt metering).

T99 FM INSTALLATION NOTES

1. EQUIPMENT HOUSING The equipment must be housed in a dry weather-proof container. No ventilation is required for less than four watts power is dissapated as heat.

Temperature stabilization will prolong component life. Several installations have utilized discarded refrigerators for ground level mounting. These are well sealed and insulated, and will average out day-night temperature fluctuations. They keep the equipment clean and improve lightning protection. Other advantages include easy installation of locks to conform with F.C.C. rule 74.1234 (3), and eye level installation for ease of meter readings.

2. POWER SOURCE For remote locations, thermoelectric powering is ideal. No batteries are required, since the thermoelectric converter delivers a regulated and well filtered 28 volts D.C. output.

Where A.C. power is available, our optional D.C.-28 power supply will deliver regulated 28 volt D.C. power for 100 to 130 volt A.C. inputs at 50 to 60 cycles. The 117 volt line should be buried for the last 200 ft. before the translator site. Power transformers and power lines should never be in line with the forward lobe of either receiving or transmitting antennas.

3. RECEIVING ANTENNAS One to four 5 or 10 element yagi antennas should be used, depending upon the received signal level and directivity required to cancel interference from noise sources or co-channel and adjacent broadcast stations or translators.

The yagi or stack must be matched to the 75 ohm input cable. Type RG-11/U foam or solid dielectric cable is satisfactory for most installations. We can supply antennas, matching cables, and instructions to phase out interference.

As a general rule the input antennas should be located about 100 ft. from any transmitting antennas. This is especially important where more than one translator is installed at a site, or when an output channel is close to the received frequency. Some single translator installations can space antennas closer, but transistors operate with low power input and are more subject to overdrive than tubes. Multiple installations may require supplemental channel filtering or trapping.

4. TRANSMITTING ANTENNAS These may be single or stacked 5 or 10 element yagis and may be skewed up to 90 degrees apart for wide coverage applications. Typical beam widths for 5 element yagis with horizontal polarization are 50 degrees between half power point. Ten element yagis average 35 degrees between half power points, vertically polarized yagi patterns are 5 to 10 degrees wider than horizontal, and are received better by automobile F.M. radios. Vertical polarization is also less subject to feedback into horizontal receiving antennas.

5. PREAMPLIFIERS If the F.M. input signal is less than 50 microvolts at 75 ohms, a preamplifier should be installed at the receiving antenna. A 20 dB. low noise preamp will extend the useable signal down to 5 microvolts.

6. RECEPTION SITE This must be chosen for the best input and minimum interference. Often this is just off the "brow" of a hill rather than on top. The antennas should be directed for maximum signal reception. This is usually down the hill slope, and not horizontal. Large towers are normally not necessary excepting on flat terrain, and may only increase maintenance problems. Most installations have their individual engineering considerations. We will assist with initial planning and in any other phase.

7. REMOTE SWITCH Where a remote switch is required, we can supply an optional wire controlled external unit. It is "fail safe", and incorporates a meter which doubles as a remote power voltage check point.

8. CONTROL LEVELS Never operate the power output at over one watt. This would be in violation of F.C.C. rules and may distort the modulation of stereo and SCA subcarriers. The T99 FM may be operated at less than one watt when licensed accordingly. This conserves battery source power and is often fully satisfactory for small communities.

T99 FM MAINTENANCE NOTES

1. T99 FM's have been in continuous operation for several years in both arctic and tropical climates outside the U.S.A. T-99 television translators are very similar, and hundreds of these have operated in all climates for up to seven years with no maintenance.

Correct operation should be verified by an annual check of the metering positions, and comparison with the previously recorded readings.

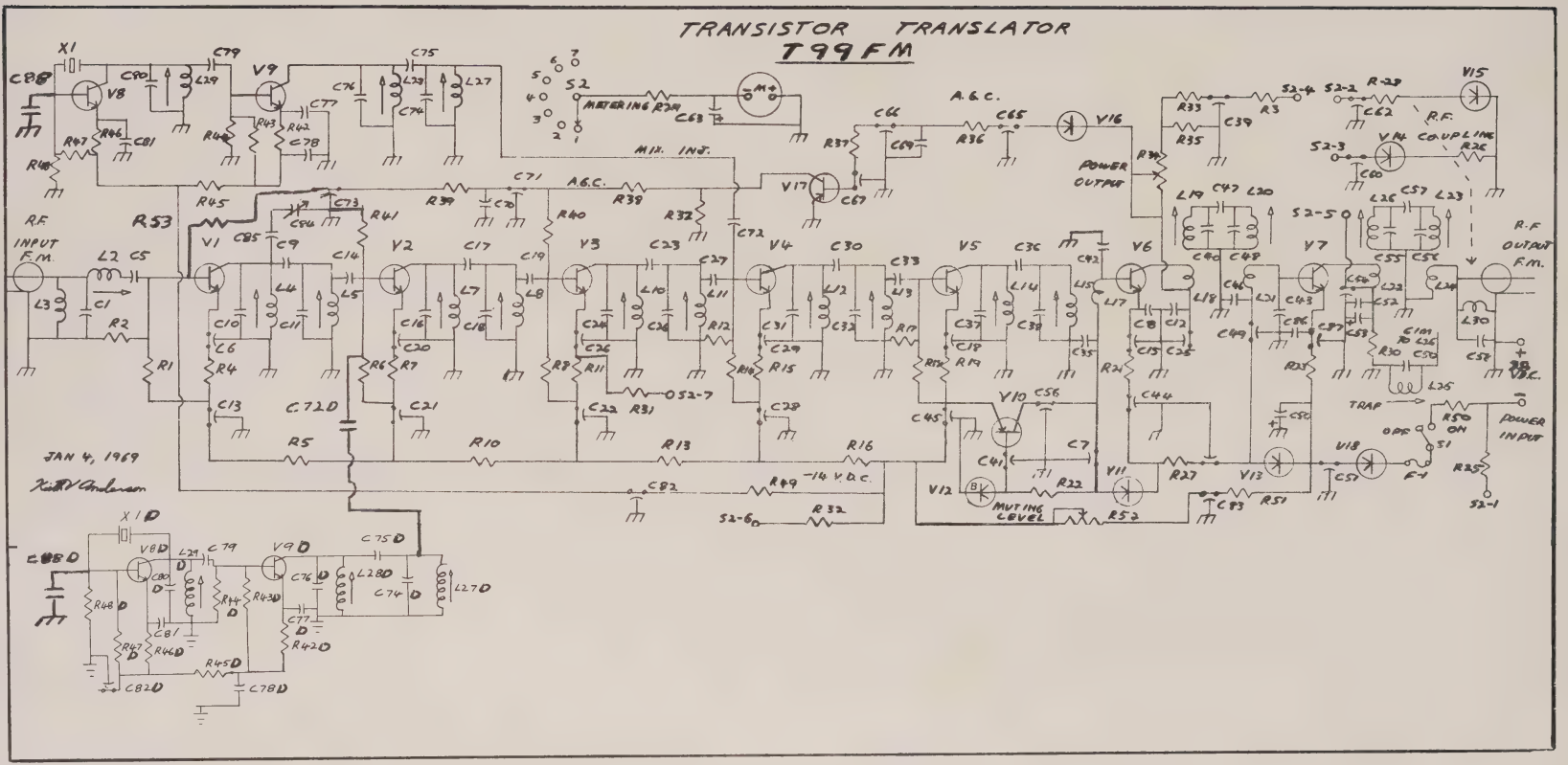
2. Lightning damage is very unlikely, because a direct short circuit is designed into the input and output terminals to cancel antenna line charges. A.C. to D.C. power supplies are subject to lightning damage from the line, but all rectifiers and other components are operated at a fraction of their ratings. All housings and towers should be connected to a moist earth ground with aluminum wire.

3. Because of the light weight of the T99 FM (12 pounds unit weight, 16 pounds shipping weight), factory service is most practical if ever required. Either air or surface parcel post is most satisfactory. Units must always be double packaged to prevent shipping damage. All warranty is cancelled for equipment with any internal changes.

4. No field alignment should ever be required or attempted.

5. The T99 FM will give years of trouble free service, if the following considerations are rigidly observed.

(a) Be certain the housing is dry and weatherproof.
(b) The power source must be a uniform well filtered and regulated 28 volts D.C.
(c) Use heavy duty yagi antennas with well sealed connectors. (We can supply these).
(d) Fasten coaxial cable rigidly to antennas and tower without swinging spans.
(e) Use short self supporting towers, then guy them for extra wind at elevated sites. Keep the guy wires more than five feet from any antennas.
(f) Ground all system components.


TRANSISTOR TRANSLATOR
T99FM
JAN 4, 1969
Kirby Anderson

T99 FM RESISTORS

SYMBOL	VALUE	SYMBOL	VALUE
R1	10,000	R2	47,000
R3	4,700	R4	470
R5	10	R6	10,000
R7	1,000	R8	100,000
R10	10	R11	470
R12	10,000	R13	100
R14	1,000	R15	270
R16	10	R17	10,000
R18	1,000	R19	68
R21	4.7	R22	2,700
R23	3.9	R25	470,000
R26	150	R27	10
R28	150	R29	100
R30	1.3	R31	150,000
R33	1,000	R34	0-500
R35	10	R36	100
R37	100	R38	100
R32	47,000	R39	100
R40	470	R41	47,000
R42 & R42D	1,000	R43 & R43D	4,700
R44 & R44D	47,000	R45 & R45D	100
R46 & R46D	1,000	R47 & R47D	4,700
R48 & R48D	47,000	R49 & R49D	1,000
R50	4.7	R51	470
R52	0-500	R53	1,000

All resistors are 1/2 watt, 10% tolerance. Power output and muting controls are linear.

T99 FM CAPACITORS

C1	68	C5	2.2
C6	FT-1000	C7	FT-1000
C8	2000	C9	.5
C10	10	C11	10
C12	2000	C13	FT-1000
C14	4.7	C15	FT-1000
C16	10	C17	.5
C18	10	C19	FT-1000
C20	FT-1000	C21	FT-1000
C22	FT-1000	C23	.5
C24	10	C25	FT-1000
C26	FT-1000	C27	4.7
C28	FT-1000	C29	FT-1000
C30	.5	C31	10
C32	10	C33	4.7
C34	FT-1000	C35	2,000
C36	.5	C37	10

T99 FM CAPACITORS

SYMBOL	VALUE	SYMBOL	VALUE
C38	10	C39	FT-1000
C40	10	C41	FT-1000
C42	50	C43	50
C44	FT-1000	C45	FT-1000
C46	2000	C47	.5
C48	10	C49	FT-1000
C50	50 mfd. 50v.	C51	FT-1000
C52	2000	C53	50 mfd. 50v.
C54	FT-1000	C55	10
C56	10	C57	.5
C58	68	C60	FT-1000
C62	FT-1000	C63	50 mfd. 50v.
C64	FT-1000	C65	FT-1000
C66	FT-1000	C67	FT-1000
C69	10,000	C70	50 mfd. 50v.
C71	FT-1000	C72	4.7
C73	FT-1000	C74 & C74D	10
C75 & C75D	1	C76 & C76D	10
C77 & C77D	470	C78 & C78D	470
C79 & C79D	10	C80 & C80D	10
C81 & C81D	470	C82 & C82D	FT-1000
C83	FT-1000	C84	1 to 5 pf.
C85	2.2	C86	2000
C87	FT-1000	C88	7.5

All capacitor values are in pico farad, unless specified otherwise. Pf values are ceramic type. FT are feed through ceramics.

T99 FM SEMICONDUCTORS

V1	2N3291	V2	2N3291
V3	2N3291	V4	2N3291
V5	2N3291	V6	2N3664
V7	2N3375	V8 & V8D	2N3291
V9 & V9D	2N3291	V10	2N4918
V11	1N4004	V12	1N965A
V13	1N4004	V14	1N34A
V15	1N34A	V16	1N4004
V16	2N3906	V18	1N4004

T99 FM OTHER COMPONENTS

SYMBOL	DESCRIPTION
F1	1/4 Amp, A.G.C. fuse
M	100 Micro amp meter
X1 & X1D	Overtone Crystals
S1	S.P.S.T. Switch
S2	Twelve position switch

When ordering components, please show component number and value, and the serial number and channels of the translator